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Description

The present invention relates to a semiconductor manufacturing apparatus and, in particular, to a cold-walled type parallel-flat-electrode plasma CVD (chemical vapor deposition) apparatus.

Figs. 4A and 4B, each, are a diagrammatic view showing an arrangement of a conventional cold-walled type plasma CVD apparatus, Figs. 4A and 4B showing a plan view and cross-sectional view, respectively, of the apparatus. A plasma SiO film is formed by the apparatus on the surface of a wafer. In the apparatus shown in Figs. 4A and 4B, reference numerals 11, 12 and 13, 14 represent a reaction chamber made of a metal such as stainless steel, an RF (radio frequency) power source and a pair of electrodes, upper and lower, for plasma generation, respectively, the upper electrode containing a heater. The reaction chamber 11 and lower electrode 14 are normally grounded. Reference numerals 15, 16, 17, 18, 19, 20, 21 and 22 shows a heater power source, a load-lock chamber (vacuum back-up chamber), a semiconductor wafer, a transfer system, a gas inlet, a reaction chamber's exhaust port, an inlet line (N_2 inlet) and a load-lock exhaust port, respectively.

In this apparatus, a predeposition step before loading a wafer into a location of the reaction chamber 11 is carried out to allow a 1.0 μm -thick plasma SiO film to be deposited in the reaction chamber 11. Then a wafer 17 is loaded via the load-lock chamber 16 into the reaction chamber 11 such that it is set on a location, and a plasma SiO film of a predetermined thickness is deposited on the wafer. The deposition of the plasma SiO film is repeated until a total thickness reaches 20 μm (this film thickness is regulated by its uniformity and dust level). At that time, a plasma dry etching is conducted using a CF_4/O_2 gas and cleaning step is performed in the reaction chamber 11 -- a first cleaning step. The plasma dry etching steps are repeated six times in terms of the dust level as well as the maintaining of a uniform film thickness, and then a mechanical cleaning -- a second cleaning step -- is performed whereby the electrodes 13, 14 and inner wall of the reaction chamber 11 are mechanically surface-cleaned.

A cold-walled type plasma CVD apparatus includes a transfer system 18 for loading and unloading a wafer 17 into and out of the reaction chamber 11 and is generally of such a type that, as shown in Fig. 4A, a side wall 11a for allowing access of the wafer 17 to the reaction chamber 11 is provided nearer to the electrodes 13, 14 than the remaining side wall of the chamber, as indicated by a distance t in Fig. 4B.

After the total deposition thickness of the plasma SiO_2 film reaches 20 μm (1.0 μm at the

predeposition step + 19.0 μm at the batch process), a plasma dry etching is performed, in the CF_4/O_2 gas stream, at

- 5 (1) an amount of flow: 450/50 SCCM;
- (2) a pressure: 33.3 Pa (0.25 Torrs);
- (3) a temperature: 300 °C; and
- (4) a power output: 2.8 KW

until a 40% overetching is obtained at which time an electric field is concentrated between the electrodes 13 and the side wall 11a at a wafer access opening location as indicated by the distance t in particular in Figs. 4A and 4B so that an abnormal discharge is produced. In an abnormal discharge zone, a greater amount of polymers including a C-F bond is formed due to an excess presence of F radicals (active radicals) not spent by a plasma SiO etching step, C radicals not consumed by oxygen in the plasma SiO film; and so on, so that the polymers are deposited on the electrode 13, 14 and on the side wall of the reaction chamber. The deposition of the C-F polymers is increased each time a plasma dry etching is effected. As a result, the reaction chamber 11 is placed under an unstable condition, failing to obtain a uniform deposition film thickness on the wafer 17.

After the 1.0 μm -thick SiO film was formed at the predeposition step, it is necessary to, in order to satisfy the uniformity requirement under the standard (under ±5% in the wafer), stabilize the inner conditions of the reaction chamber by performing a given number of plasma dry etchings upon the deposition film thickness of a dummy wafer and to perform a mechanical cleaning step at a rate of once per five plasma dry etching steps so that the C-F polymers may be removed out of the surface wall of the chamber.

Let it be assumed that a throughput is obtained per working hour of 500 h/month at an operation rate of 0.8, by 5 plasma dry etchings (etching rate: 0.08 $\mu\text{m}/\text{min}$ (800 Å/M), 40% overetching rate) and 1 mechanical cleaning step in one process, while being at a plasma SiO deposition film thickness of 1.0 μm at a predeposition step (deposition rate: 0.06 $\mu\text{m}/\text{min}$ (600 Å/M)) and a plasma SiO deposition film thickness of 19 μm at a batch process (10 wafers can be treated by one batch). In this case, it is possible to obtain a yield of only about 150 lots per month due to a need to perform a predeposition step.

That is, with the conventional plasma CVD apparatus, an abnormal discharge is generated particularly at a zone between the electrode and the side wall section of the reaction chamber. Since, in this case, the aforementioned C-F polymers are formed on the electrodes and the side wall of the reaction chamber, and chamber room are out of condition, and the thickness of the deposition are increased. It is necessary to perform a deposition

step of dummy wafer and many mechanical cleaning step so that the C-F polymers may be removed from the inner wall of the reaction chamber. This causes a marked decline in the manufacturing efficiency.

A plasma chemical vapor deposition apparatus according to the preamble of claim 1 is known from EP-A-0 115 970, the apparatus being provided for etching substrates by reactive plasma.

It is the object of the present invention to provide a plasma CVD apparatus which can prevent a deposition of an undesired material on a surrounding surface which results from an abnormal discharge between the electrodes and a side wall of a reaction chamber.

This object is solved according to the present invention by a plasma chemical vapor deposition apparatus including the features of claim 1.

The plasma CVD apparatus of the present invention comprises a reaction chamber (11), electrodes (13, 14) and a side wall portion 11a which constitutes part of the reaction chamber (11) covered at least its portion with an insulating member, the side wall portion (11a, 11d) having a wafer transfer opening.

In the plasma CVD apparatus of the present invention, the side wall (11a, 11d) is situated at a relatively close distance from the electrode with a wafer access opening formed as the wafer transfer opening, and covered with the insulating member (31), thereby preventing any abnormal discharge between the electrode and the side wall near the electrode. The partition wall having the wafer transfer opening defines a minimal distance relative to the electrode in terms of wafer transfer and an abnormal discharge is, therefore, most liable to occur at the zone. Since the abnormal discharge is prevented by the insulating member on the side wall of the reaction chamber, it is possible to suppress the deposition of C-F polymers, etc. on the inner wall of the chamber so that the reaction chamber is placed in a stabler state. It is thus possible to maintain a uniform deposition film level on the wafer and hence to achieve, for example, an improved throughput.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

- Fig. 1A is a plan view showing a plasma CVD apparatus according to one embodiment of the present invention;
- Fig. 1B is a cross-sectional view showing the plasma CVD apparatus shown in Fig. 1A;
- Fig. 2 is a cross-sectional view showing a major portion of the plasma CVD apparatus of Fig 1;
- Fig. 3 is a graph showing a relation to the thickness of a deposit film as shown in connec-

tion with the effect of the present invention; Figs. 4A and 4B are a plan view and cross-sectional view showing a plasma CVD apparatus to which the present invention is not applied; Fig. 5 is a cross-sectional view showing a major portion of a plasma CVD apparatus according to another embodiment of the present invention; Fig. 6 is a cross-sectional view showing a major portion of the plasma CVD apparatus according to another embodiment of the present invention; Fig. 7A is a plan view showing a plasma CVD apparatus according to another embodiment of the present invention; and Fig. 7B is a cross-sectional view showing the plasma CVD apparatus of Fig. 7A.

An embodiment of the present invention will be explained below with reference to the accompanying drawings.

Figs. 1A and 1B are a plan view and cross-sectional view, respectively, showing an embodiment of the present invention with identical reference numerals employed to designate identical parts or elements. In a cold-walled type plasma CVD apparatus, as shown in Fig. 1, having a wafer transfer system relative to a reaction chamber 11, an insulating member 31, such as a 3 mm-thick alumina sheet, is secured by alumina screws to the surface of that side wall 11a facing part of a reaction chamber 11 with a wafer access opening left in the side wall 11a.

It is desirable that the insulating member 31 extend inward along an inner edge portion 11b of the wafer access opening as shown in Fig. 2 because an electric field across the reaction chamber's side wall and discharge electrodes 13, 14 is liable to be concentrated toward the edge portion 11b. The insulating member 31 may also be made of, for example, Si_3N_4 and SiO_2 , provided that they are heat-resistant, over 300°C , and desirably never contain any contamination source for a semiconductor, such as Na, K, Cu, Fe, Ni, Cr, C and At. In Figs. 1A, 1B and 2, 32, 33 and 34 denote windows and packing, respectively.

From the standpoint of the location of the wafer transfer mechanism, since the inner surface of the side wall 11a of the reaction chamber 11 is insulated by the insulating member 31 relative to the discharge electrodes 13, 14 at that minimum distance zone which is defined adjacent the wafer access opening, this distance zone is can be regarded as being electrically equal to or greater than the distance of the rest of the inner wall of the chamber which is defined relative to the discharge electrode. It is thus possible to suppress the concentration of an electric field at the location between the side wall 11a adjacent the wafer access opening and the discharge electrode. The suppression of the electric field has been confirmed as will

be set forth below.

After the deposition of a plasma SiO film to a total thickness 20 μm of 1.0 μm at a predeposition step and 19 μm at a batch process, a plasma dry etching step is performed, in the CF_4/O_2 stream, at a 450/50 SCCM, a pressure of 33.3 Pa (0.25 Torrs) and 300°C with a power output 2.8 KW to achieve a 40% overetching. From an observation of the interior of the chamber through a view window opened at the side wall of the chamber it has been found that no abnormal discharge occurs due to the concentration of an electric field between the electrode and the side wall 11a of the reaction chamber 11 which is situated adjacent the wafer access opening.

It has also been found that, upon the repeated deposition of a plasma SiO film (a total deposition film thickness 20 μm) and plasma dry etching, the reaction chamber is placed in a stable state in terms of uniformity of the film thickness and dust level.

In the cold walled type plasma CVD apparatus having a wafer transfer system 18 to the reaction chamber 11, the insulating member 31 is provided near the wafer access opening in a manner as set forth above whereby it is possible to regard the minimum distance zone between the chamber's side wall 11a adjacent the wafer access opening and the discharge electrodes 13, 14 as being electrically equal to and greater than the remaining zone of the reaction chamber which is associated with the electrodes. This specific arrangement can suppress the deposition of C-F polymers resulting from an "abnormal discharge" phenomenon caused by the concentration of an electric field, assuring a high stability in the reaction chamber.

It is until a total deposition film thickness reaches 20 μm and 30 μm , each, that, due to the interior of the reaction chamber set in an enhanced stable condition, the film uniformity falls within a standard ($\pm 5\%$ in the wafer) immediately following the predeposition of the SiO film to the thickness 1.0 μm . It has been found not necessary to perform a deposition of dummy wafer step per 8 plasma dry etching steps. A single mechanical cleaning step for eliminating C-F polymers is sufficient in performing eight plasma dry etching steps. The term "BP1" in Fig. 3 means a first cycle in the batch process. It is not necessary, therefore, to perform more predeposition step. For a total deposition film thickness of 30 μm , it is only necessary to perform eight plasma dry etching steps and a single mechanical cleaning step. The other conditions being equal to those of the conventional case, the throughput becomes 260/month, that is 1.73 times as high as that of the conventional case.

Here, Figs. 5 and 6, each, are a cross-sectional view showing a major part of a plasma CVD ap-

paratus according to another embodiment of the present invention. In the embodiment shown in Fig. 5, an insulting member 31 is provided not only on a side wall constituting part of a reaction chamber 11 of a plasma CVD apparatus but also an access door 33 for wafer transfer. Since the access door 33 relatively near electrodes is covered with the insulating member, it is possible to more positively prevent an abnormal discharge.

The edge of an access opening near a side wall 11c of a reaction chamber is chamfered in the arrangement shown in Fig. 5, preventing an abnormal discharge from concentrating an otherwise sharp edge of the wafer access opening from the electrodes.

Fig. 6 shows a shield sheet 40 for closing a wafer access opening at a specific location of a reaction chamber whereby it is possible to prevent an abnormal discharge in the neighborhood of a conductive door. A movable motor, for example, is provided so that a wafer is transferred to the interior of the reaction chamber.

Fig. 7A is a side view showing a plasma CVD apparatus according to another embodiment of the present invention. Fig. 7B are a plan view showing the plasma CVD apparatus. In this embodiment, an insulating member 11a is provided on a side wall 11a of a reaction chamber 11 situated adjacent an access opening and on the remaining side wall portion 11d of the reaction chamber 11. It is thus possible to more positively prevent the development of an abnormal discharge from electrodes. The insulating member may be provided on an area relatively near the side wall 11d or on a whole surface of the side wall of the reaction chamber. Furthermore, the side walls 11a, 11d are initially made of an insulating member in place of a conductive member, making it possible to more positively prevent an abnormal discharge.

In the cold-walled type plasma CVD apparatus, according to the present invention, which includes a wafer transfer system to the reaction chamber, an electric field concentration is prevented between the electrodes and the side wall of the reaction chamber into which a wafer is loaded in the time of plasma etching. It is, therefore, possible to suppress deposition of C-F polymers etc., to achieve an enhanced stability in the reaction chamber and to obtain a higher throughput while achieving a stable deposition film uniformity level.

Claims

1. A plasma chemical vapor deposition apparatus comprising:
a reaction chamber (11);
electrodes (13, 17) provided in the reaction chamber; and

a side wall (11a) constituting part of the reaction chamber and having a wafer access opening,

characterized in that

at least the surface of the side wall is covered with an insulating plate (31), whereby the insulating plate prevents an unusual plasma discharge between the electrodes and the side wall.

2. A plasma chemical vapor deposition apparatus according to claim 1, characterized by further comprising a second side wall (11d) is provided whose wafer access opening is not covered with said insulating plate.
3. A plasma chemical vapor deposition apparatus according to claim 1 or 2, characterized in that said insulating plate (31) has a resistance to a temperature at least as high as 300 °C or over.
4. A plasma chemical vapor deposition apparatus according to claim 3, characterized in that said insulating plate (31) comprises material which does not supply contamination substance.
5. A plasma chemical vapor deposition apparatus according to claim 3, characterized in that said insulating plate (31) includes alumina.
6. A plasma chemical vapor deposition apparatus according to claim 3, characterized in that said insulating plate (31) includes Si₃N₄.
7. A plasma chemical vapor deposition apparatus according to claim 3, characterized in that said insulating plate (31) includes SiO₂.
8. A plasma chemical vapor deposition apparatus according to claim 1 or 2, characterized in that said first side wall (11a) is wholly covered with said insulating plate (31).
9. A plasma chemical vapor deposition apparatus according to claim 1 or 2, characterized in that said insulating plate (31) and said first side wall (11a) are chamfered at least at an area near said electrodes.
10. A plasma chemical vapor deposition apparatus according to claim 1 or 2, characterized by further comprising a door (33) covered with said insulating plate (31) and adapted to close said wafer access opening in said side wall.
11. A plasma chemical vapor deposition apparatus according to claim 1 or 2, characterized in that said insulating plate (31) is secured by screws

to at least one of said first or second side wall (11d) of said reaction chamber.

- 5 12. A plasma chemical vapor deposition apparatus according to claim 1 or 2, characterized by further comprising a shield sheet (40) including said insulating plate (31) and adapted to close said wafer access opening in said first side wall from inside said reaction chamber.
- 10 13. A plasma chemical vapor deposition apparatus according to Claim 1, characterized in that said insulating plate includes an alumina plate having a thickness of at least 3 mm.

Patentansprüche

- 20 1. Vorrichtung zur plasma-chemischen Gasphasenabscheidung, mit:
einer Reaktionskammer (11);
Elektroden (13, 17), die in der Reaktionskammer vorgesehen sind; und
einer Seitenwand (11a), die einen Teil der Reaktionskammer bildet und die eine Waferzugangsöffnung aufweist,
dadurch gekennzeichnet, daß
zumindest die Oberfläche der Seitenwand mit einer Isolatorplatte (31) abgedeckt ist, wodurch die Isolatorplatte eine ungewöhnliche Plasmatladung zwischen den Elektroden und der Seitenwand verhindert.
- 25 2. Vorrichtung zur plasma-chemischen Gasphasenabscheidung nach Anspruch 1,
dadurch gekennzeichnet, daß
ferner eine zweite Seitenwand (11d) vorgesehen ist, deren Waferzugangsöffnung nicht mit der Isolatorplatte abgedeckt ist.
- 30 35 3. Vorrichtung zur plasma-chemischen Gasphasenabscheidung nach Anspruch 1 oder 2,
dadurch gekennzeichnet, daß
die Isolatorplatte (31) eine Wärmebeständigkeit von mindestens 300 °C aufweist.
- 40 45 4. Vorrichtung zur plasma-chemischen Gasphasenabscheidung nach Anspruch 3,
dadurch gekennzeichnet, daß
die Isolatorplatte (31) ein Material umfaßt, welches keine kontaminierenden Substanzen zur Verfügung stellt.
- 50 55 5. Vorrichtung zur plasma-chemischen Gasphasenabscheidung nach Anspruch 3,
dadurch gekennzeichnet, daß
die Isolatorplatte (31) Aluminiumoxid enthält.

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6. Vorrichtung zur plasma-chemischen Gasphasenabscheidung nach Anspruch 3, dadurch gekennzeichnet, daß die Isolatorplatte (31) Si_3N_4 enthält. 5
7. Vorrichtung zur plasma-chemischen Gasphasenabscheidung nach Anspruch 3, dadurch gekennzeichnet, daß die Isolatorplatte (31) SiO_2 enthält. 10
8. Vorrichtung zur plasma-chemischen Gasphasenabscheidung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die erste Seitenwand (11a) vollständig mit der Isolatorplatte (31) abgedeckt ist. 15
9. Vorrichtung zur plasma-chemischen Gasphasenabscheidung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Isolatorplatte (31) und die erste Seitenwand (11a) zumindest in einem Bereich nahe der Elektroden abgeschrägt sind. 20
10. Vorrichtung zur plasma-chemischen Gasphasenabscheidung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß diese ferner eine Tür (33) aufweist, die mit der Isolatorplatte (31) bedeckt ist und die die Waferzugangsoffnung in der Seitenwand verschließen kann. 25
11. Vorrichtung zur plasma-chemischen Gasphasenabscheidung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Isolatorplatte (31) mit Schrauben an zumindest einer der ersten oder zweiten Seitenwand (11d) der Reaktionskammer befestigt ist. 30
12. Vorrichtung zur plasma-chemischen Gasphasenabscheidung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß diese ferner eine Abschirmplatte (40) aufweist, welche die Isolatorplatte (31) enthält und die die Waferzugangsoffnung in der ersten Seitenwand von dem Inneren der Reaktionskammer verschließen kann. 35
13. Vorrichtung zur plasma-chemischen Gasphasenabscheidung nach Anspruch 1, dadurch gekennzeichnet, daß die Isolatorplatte eine Aluminiumoxidplatte mit einer Dicke von mindestens 3 mm aufweist. 40
- Revendications**
1. Appareil de dépôt chimique en phase vapeur utilisant un plasma comprenant : 55 une chambre de réaction (11) ; des électrodes (13, 17) placées dans la chambre de réaction ; et une paroi latérale (11a) constituant une partie de la chambre de réaction et ayant une ouverture d'accès pour les plaquettes, caractérisé en ce que au moins la surface de la paroi latérale est couverte d'une plaque isolante (31), où la plaque isolante empêche une décharge inhabituelle utilisant un plasma entre les électrodes et la paroi latérale.
2. Appareil de dépôt chimique en phase vapeur utilisant un plasma selon la revendication 1, caractérisé en outre ce qu'une seconde paroi latérale 11d est fournie dont une ouverture d'accès pour les plaquettes n'est pas couverte avec ladite plaque isolante.
3. Appareil de dépôt chimique en phase vapeur utilisant un plasma selon la revendication 1 ou 2, caractérisé en ce que ladite plaque isolante (31) a une résistance à une température d'au moins 300°C ou plus.
4. Appareil de dépôt chimique en phase vapeur utilisant un plasma selon la revendication 3, caractérisé en ce que ladite plaque isolante (31) comprend une matière qui ne doit pas fournir une substance de contamination.
5. Appareil de dépôt chimique en phase vapeur utilisant un plasma selon la revendication 3, caractérisé en ce que ladite plaque isolante (31) comprend de l'alumine.
6. Appareil de dépôt chimique en phase vapeur utilisant un plasma selon la revendication 3, caractérisé en ce que ladite plaque isolante (31) comprend du Si_3N_4 .
7. Appareil de dépôt chimique en phase vapeur utilisant un plasma selon la revendication 3, caractérisé en ce que ladite plaque isolante (31) comprend du SiO_2 .
8. Appareil de dépôt chimique en phase vapeur utilisant un plasma selon la revendication 1 ou 2, caractérisé en ce que ladite première paroi latérale (11a) est entièrement recouverte avec ladite plaque isolante (31).
9. Appareil de dépôt chimique en phase vapeur utilisant un plasma selon la revendication 1 ou 2, caractérisé en ce que ladite plaque isolante (31) et ladite première paroi latérale (11a) sont chanfreinées sur au moins une zone proche desdites électrodes.

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10. Appareil de dépôt chimique en phase vapeur utilisant un plasma selon la revendication 1 ou 2, caractérisé en ce qu'il comprend en outre une porte (33) couverte avec ladite plaque isolante (31) et adapté pour fermer ladite ouverture d'accès pour les plaquettes dans ladite paroi latérale.

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11. Appareil de dépôt chimique en phase vapeur utilisant un plasma selon la revendication 1 ou 2, caractérisé en ce que ladite plaque isolante (31) est fixée par des vis sur au moins une desdites première ou seconde parois latérales (11d) de ladite chambre de réaction.

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12. Appareil de dépôt chimique en phase vapeur utilisant un plasma selon la revendication 1 ou 2, caractérisé en ce qu'il comprend une feuille de protection (40) comprenant ladite plaque isolante (31) et adaptée pour fermer ladite ouverture d'accès pour les plaquettes dans ladite première paroi latérale à partir de l'intérieur de ladite chambre de réaction.

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13. Appareil de dépôt chimique en phase vapeur utilisant un plasma selon la revendication 1, caractérisé en ce que ladite plaque isolante comprend une plaque d'alumine ayant une épaisseur d'au moins 3 mm.

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FIG. 1A

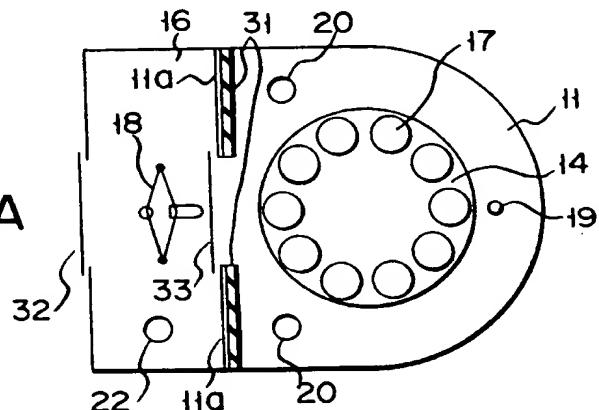


FIG. 1B

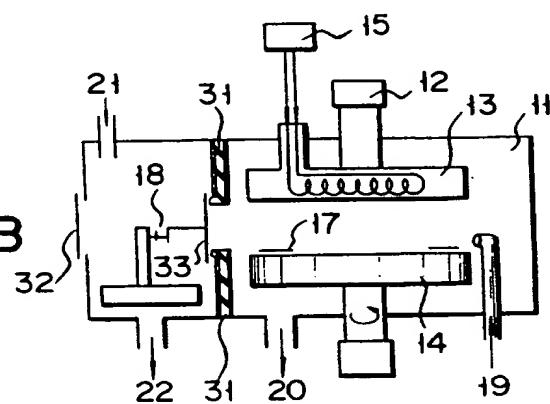
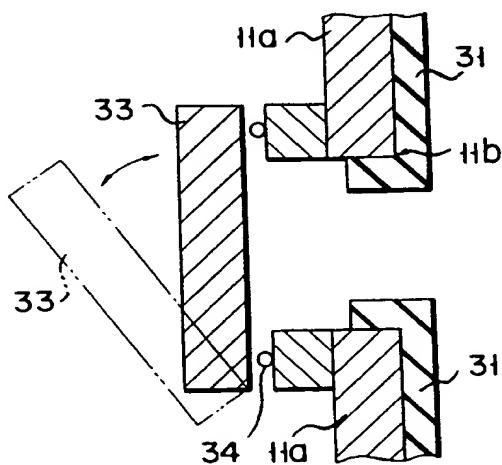
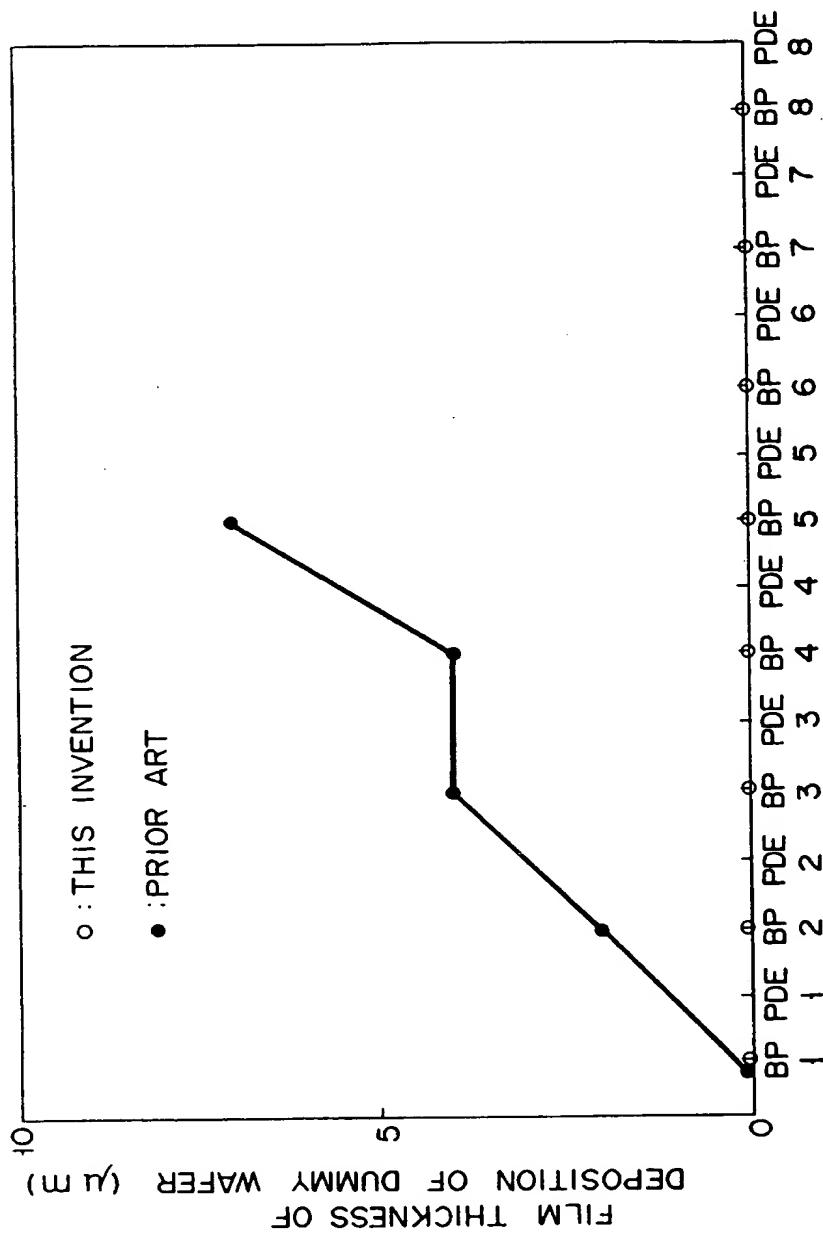


FIG. 2



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G.
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E.

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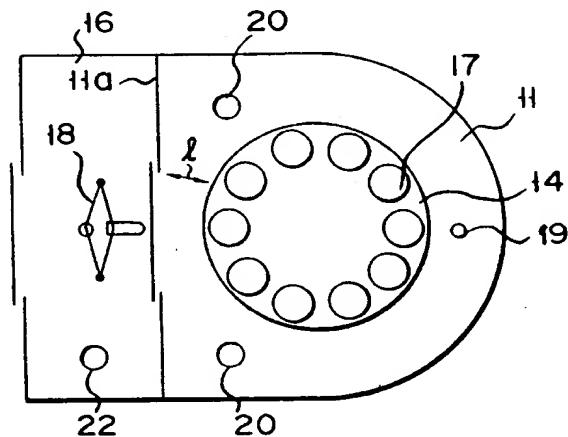


FIG. 4A

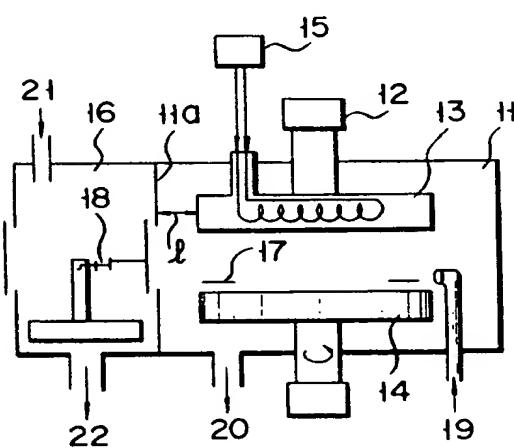


FIG. 4B

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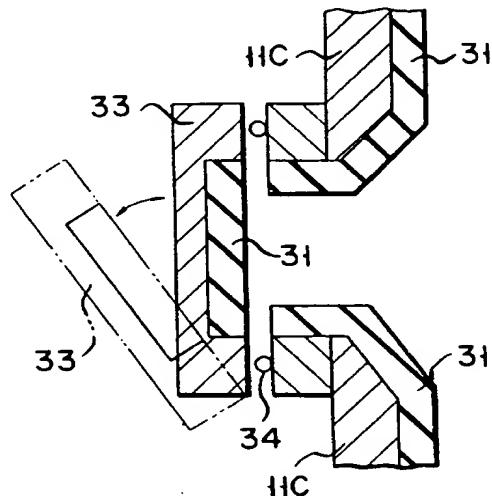


FIG. 5

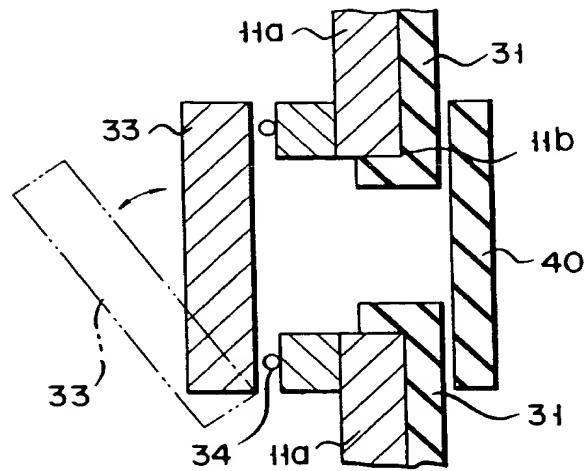
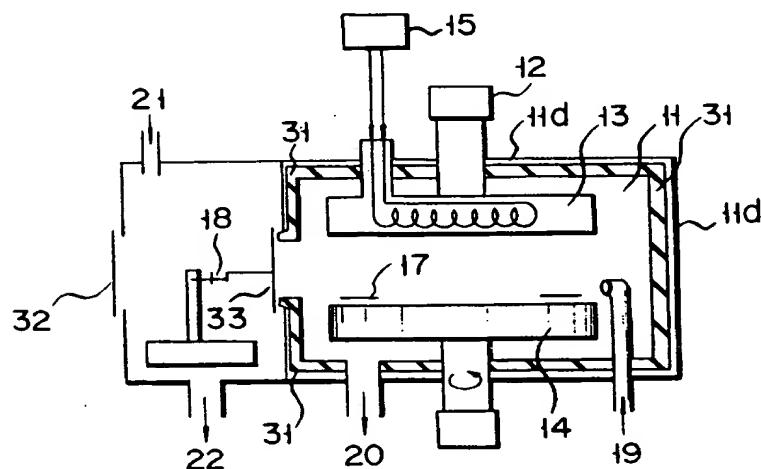
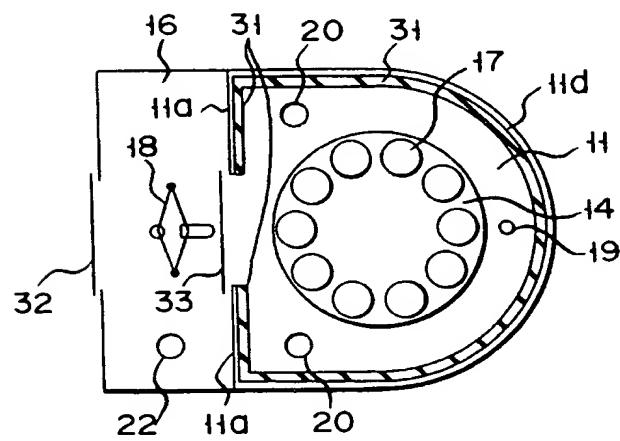


FIG. 6

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F I G. 7A



F I G. 7B